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Research Department Report

ALLEVIATION OF CO-CHANNEL INTERFERENCE AT POOLE RELAY STATION

J.H. Moore *and* A.I.E. Booker

Research Department, Engineering Division
THE BRITISH BROADCASTING CORPORATION

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Summary

The Rowridge UHF television transmitting station, situated on the Isle of Wight, radiates the four principal UK domestic television channels to the south coast of England, and provides an off-air feed to a number of dependent relays. At one relay station (Poole), occasional Co-channel Interference (CCI) is known to occur. It is particularly noticeable during the summer and autumn periods. Large numbers of domestic viewers along the south coast (receiving Rowridge directly) are also affected by CCI.

The dominant source of interference on the Re-broadcast Link (RBL) from Poole had been shown from previous investigations to be the French TV station at Lille Bouvigny, which is co-channel with three of the Rowridge channels (BBC-2, ITV and Channel 4); BBC-1 is virtually free of CCI. The bearings from Poole to Rowridge and Lille Bouvigny differ by only 3.5 degrees; far too small a value for the Poole receiving antennas to provide any discrimination between these two stations — unimportant when tropospheric conditions are not favouring anomalous UHF propagation, but a significant weakness when such conditions do pertain.

Of several possible solutions for reducing the CCI along the south coast, that of providing precision offset of the affected channels' RF carriers was the one chosen. The Lille Bouvigny transmitter already employed such carrier offsets. Only BBC-2 was dealt with, so that comparisons with the other two affected channels could be made. This Report gives the details of the tests that were carried out, the selection of the method for producing an improvement to TV reception from Rowridge, and the notable benefits achieved.

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Ian Childs

Head of Research Department

Research Department, Engineering Division
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1. INTRODUCTION

The United Kingdom, in common with many European countries, uses Ultra High Frequencies (UHF) for the broadcasting of its domestic television services; these are in Band IV (470 - 582 MHz) and Band V (614 - 854 MHz) and are occupied by television channels 21 - 34 and 39 - 68 respectively. In order that a service is available to as many areas as possible, it is necessary to reuse the same channel frequencies many times. Great care is then taken to prevent Co-channel Interference (CCI) by planning transmitters with adequate geographical separation. However, it is not possible to protect all areas for 100% of the time. There are likely to be days when the meteorological conditions favour anomalous UHF propagation in the troposphere, so that serious picture impairment will probably occur in some places. Usually, the problem is only annoying for short periods (the UHF network is planned to protect domestic reception for better than 95% of the time) during a particularly bad day; but when a relay station retransmits channels which have CCI present, some effort must be made to reduce the problem. The relay station at Poole in Dorset was such a case where reception was reported to suffer interference for significant periods of time.

The Poole relay station receives its Rebroadcast Link (RBL) feed from the Rowridge transmitter, which has an Effective Radiating Power (ERP) of 0.5 MW per channel; this station is situated on the Isle of Wight, with the horizontal radiation pattern of the transmitting antennas being set to beam the majority of the power in the direction of the UK mainland (Fig. 1). The signal strength received from this main transmitter is adequate for good reception at Poole; but reports of CCI on pictures received from the relay station, led to 12 months of initial investigations into the problem. These investigations were concluded in March 1986. The problem was also being experienced by many south coast households who received their signals directly from Rowridge.

The first part of the investigations was concerned with determining the source of the interference. This was concluded to be the French television transmitting station at Lille Bouvigny because this station transmits on the same channel frequencies as three of the four principal UK domestic television channels from Rowridge*, namely Channels 21, 24 and 27. It was these three channels that occasionally experienced severe CCI; usually during the summer and autumn periods, when the tropospheric conditions were particularly favourable to anomalous propagation of UHF signals.

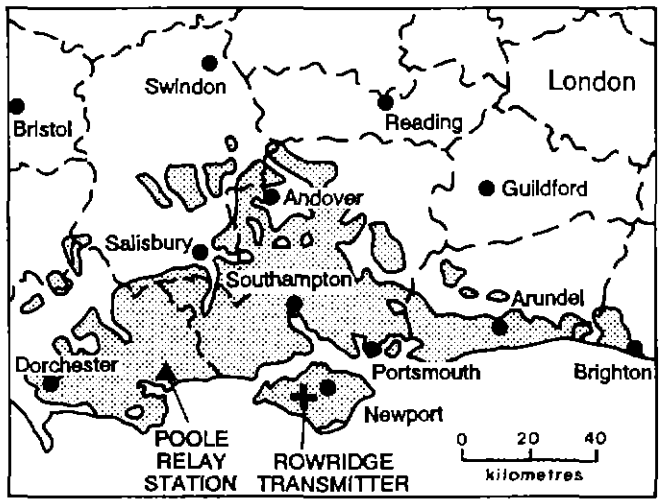

Fig. 1 - Service area for the Rowridge transmitter.

The French station at Lille Bouvigny has an ERP of 1 MW, transmitting omnidirectionally, and lies almost along the same geographic bearing, from Poole, as Rowridge. Lille Bouvigny is situated some 326 km away from Poole (Fig. 2, *overleaf*) (approximately 20 km north-west of Arras and 75 km south-east of Calais), on a bearing (from Poole) of 94.3 degrees East of Grid North. Rowridge is 41 km distant from Poole but is only 3.5 degrees south of the Lille Bouvigny bearing. (Such a small difference in these bearings did not allow the Poole receiving antennas to discriminate between the two main transmitting stations during periods of anomalous propagation: there could, therefore, only be limited doubt as to the source of the interfering signals, especially as Channel 31 was free from such interference.)

*

Rowridge transmission channels	
Channel	Programme
21	Channel 4
24	BBC-2
27	ITV
31	BBC-1

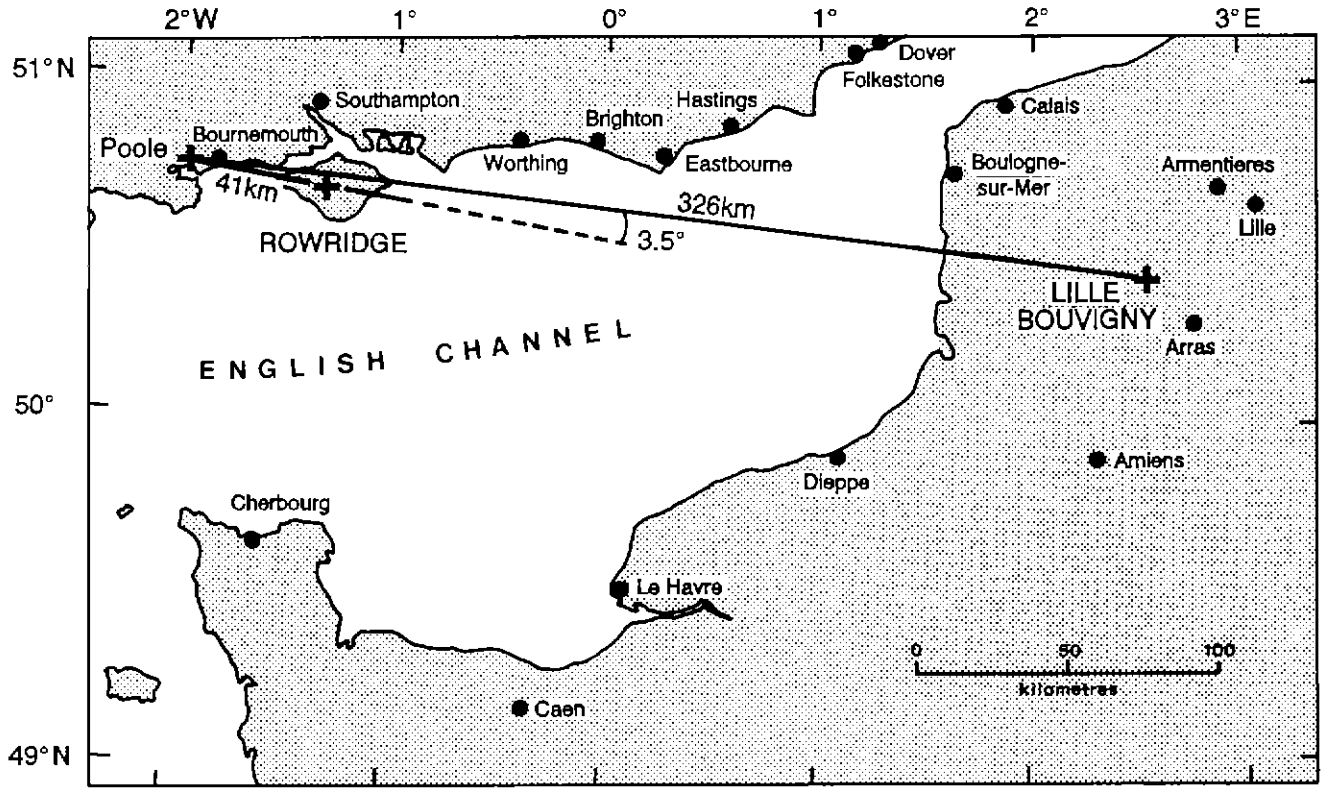

Fig. 2 - Relative locations of Poole, Rowridge and Lille Bouvigny.

A second 12 months' investigation, ending in September 1991, was used to assess the level of CCI on the RBL signal; and in particular, to quantify the benefits of precision offset when applied to the Rowridge Channel 24 transmission — this was the method finally used to reduce the effect of CCI.

2. THE MEASURING EQUIPMENT

To ascertain the severity and frequency of the reported impairments, special television picture recording apparatus (designed by BBC Research Department) was installed at the Poole relay station. The same equipment was used for both the 1985/86 and the 1990/91 investigations.

2.1 The apparatus

The equipment comprised time-controlled television picture recording apparatus and a Research Department digital field strength measuring receiver, with a paper chart recorder for recording the field strength of the Rowridge signal. The latter was only used for a few days during the 1985/86 investigation in order to confirm the basic field strength value.

The picture recording apparatus (Fig. 3) included a VHS video cassette recorder, which was controlled by a microcomputer. The computer was used to address a teletext tuner, so as to select a television channel and allow the teletext page header to appear on each recorded sample. The teletext page header showed the television service (i.e. BBC-1. BBC-2, ITV or Channel 4) as well as the date and time of each recording (see Figs. 7(a) - (d)).

2.2 The method

The microcomputer was programmed to allow, approximately, 12 seconds of sequential recordings per hour for each of the four channels. Recording commenced at about 0700 hours and subsequently every hour up to 2400 hours.

For the 1985/86 investigations, a three-hour cassette had been used, giving up to 10 days of continuous sampling. However, with the introduction of four-hour cassettes, a 14 day period of continuous sampling was possible for the 1990/91 investigations. It was the convenience of this regular picture sampling that ensured the reliability of the analysed results. The videotapes were changed at the appropriate 10/14 day intervals and then returned to BBC Research Department for analysis.

The convenience of being able to have these results available back at BBC Research Department, coupled with substantial savings in engineers' time on site, provided an effective means to carry out a year's

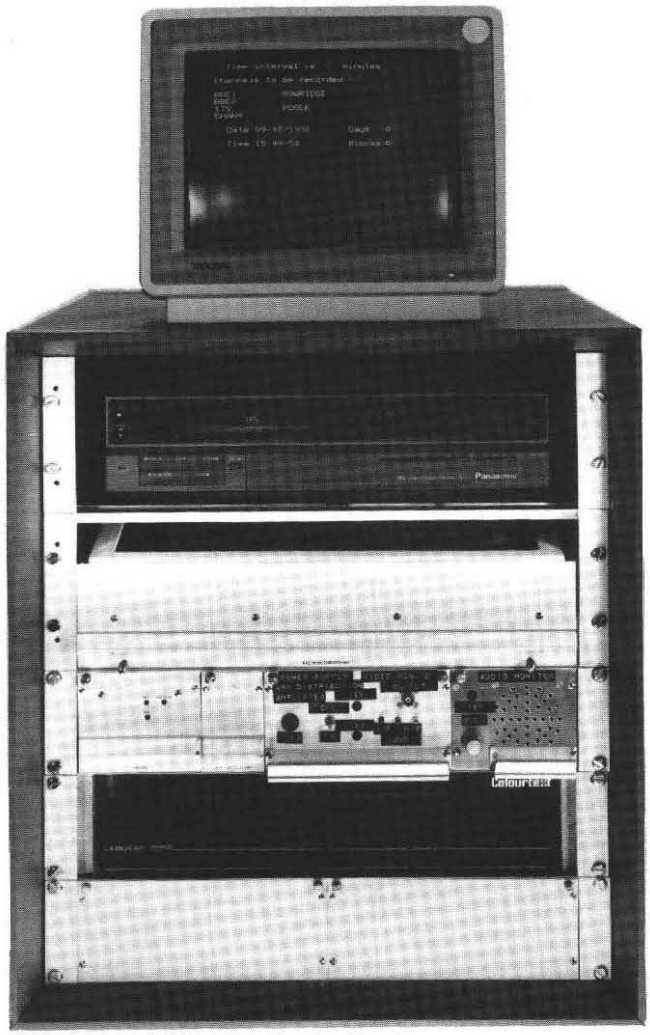

Fig. 3 - The picture recording apparatus used at Poole.

(Note that a small 'BBC microcomputer' is positioned beneath the VHS recorder, and is mounted on pull-out slider arms.)

worth of analysis with the minimum inconvenience. Also, the use of videotaped recordings enabled a more realistic assessment of the CCI to be made: it is the relative movement of the wanted picture and co-channel interferer that causes most annoyance to a viewer. (A previous method of recording had employed a 35 mm stills camera which had only given static impressions of CCI from off-screen pictures and was much less satisfactory.)

3. THE RESULTS OF MEASUREMENTS

From the initial investigation, examination of the field strength charts showed negligible variations of the channels' signal levels. From these charts, it was seen that the field strengths of the received Rowridge signals were as predicted, and similar to those measured when the site was originally surveyed.

Analysis of the video cassette tapes showed that, on occasions, both Co- and Adjacent Channel Interference (ACI) were present on the incoming signal and were, therefore, re-radiated by the Poole relay station. For each channel, this analysis provided an assessment of the incidence of interference (as a picture impairment grade on the CCIR 5-point grading scale*). About 6200 recordings were made on each channel during each investigation.

Further inspection of the tapes determined that the incidence of ACI was for just 0.6% of the time during the 12 month periods and was only seen on Channels 24 and 27. Although the source of ACI was never positively identified, it was considered reasonable to assume that the high level of signals from Stockland Hill main station, which is adjacent on these two channels only, were the origin of the problem. Stockland Hill lies on a bearing of 277.4 degrees East of Grid North from Poole at a distance of 82 km. However, ACI was not serious in comparison to CCI, so the detailed analysis concentrated on the latter. It is also possible, in cases of ACI, to use filtering in the antenna feeds to eliminate the problem.

Annual variations in the severity of CCI are brought out clearly from the sets of tabulated results for each channel. There are two sets of tables (i.e. for 1985/86 and 1990/91, after remedial steps had been taken as detailed below) and these are shown in Appendix 1, Tables 1 - 4 and 5 - 8 respectively. Tables 9 and 10 summarise the percentage of time that CCI was at Grade 2 or worse, and also Grade 3 or worse, during each investigation. But it should be pointed out, that comparisons between yearly results of assessed levels of CCI should not be made, as it is inevitable that the atmospheric conditions which allow anomalous propagation are unpredictable.

4. METHODS CONSIDERED FOR REDUCING THE EFFECTS OF CO-CHANNEL INTERFERENCE

There were two possible methods considered for alleviating the CCI at Poole; (a third method, to reduce the power of Lille Bouvigny, was clearly not a viable option).

i) The erection of a simple phased array of two log-periodic receiving antennas at Poole, for each channel affected by CCI.

* The CCIR 5-point impairment scale is as follows:

5 Imperceptible
4 Perceptible, but not annoying
3 Slightly annoying
2 Annoying
1 Very annoying

By adjusting the distance between each antenna, the unwanted signal can be phase-cancelled while leaving the wanted signal virtually unimpaired. Each channel would have needed individual antenna systems fitted. This method was considered to be a possible solution, but would only have benefited those people using the Poole relay transmissions; other local relays, and affected individual households using Rowridge directly, would not have benefited.

ii) The provision of calculated precision offset for the carriers of the affected Rowridge main transmitter channels.

This method uses a technique for ensuring the frequency alignment of the affected channel's carrier with the interfering channel's carrier. This procedure is carried out so that the interference (clearly, not eliminated) produces the minimum visible patterning, whilst *maintaining* this situation; that is, there is negligible drifting between the relative frequencies of each RF carrier; the *changes* in picture patterning being a most annoying feature for television viewers.

To achieve this situation, both transmitters must have precision offset, while the transmitter whose channels suffer the interference (Rowridge in this case), has its affected RF carriers adjusted for minimum visible picture patterning. Lille Bouvigny already had precision offset carriers (to reduce CCI of its own signals from and to another continental station). So Rowridge could then be precision offset without any reference being needed to the French authorities. Other relay stations fed from Rowridge, and individual users of the Rowridge main transmitter, would then have some of the advantage gained by the Poole relay station from this exercise. The high-stability (rubidium gas controlled) master oscillator could also be incorporated into use at Rowridge with the minimum of interruption to the service. Hence, this was the method decided upon for reducing the effects of CCI at Poole — experimentally, for the Channel 24 transmissions.

5. THE USE OF PRECISION OFFSET

At UHF (and also VHF when applicable) there is a finite amount of spectrum available for broadcasting[1]. Consequently, common frequencies have to be used by many transmitters if full national television coverage is to be obtained. This also applies (as in the case now being considered) between national boundaries; that is, each country needs to use frequencies which are used by other countries. By careful geographic placement of the transmitters, use of different signal polarisations, using no more power than is absolutely necessary, and by setting up the optimum directional characteristics of the antenna (for the area served by the transmitter), the co-channel interference problem is minimised.

Additionally, receiving antennas can reduce CCI, as a consequence of their alignment (towards the local station) being away from the distant source of the interference; thus, there may be a further rejection of CCI resulting from the directional characteristics of a proportion of receiving antennas — this was not the case for the Poole relay station!

The one other protection factor that can be offered, is that of using carrier frequency *offset*. This process does not prevent a 'clash' of commonly-used channels during periods of anomalous tropospheric propagation; it is a means of *reducing* the annoyance caused to the viewer by any resulting picture interference during such conditions.

The interference to the picture results from the heterodyne beat between wanted and unwanted carriers and sidebands, but the frequency difference is small. The interference takes the form of striations across the screen and has the appearance of a venetian blind — perhaps, with the occasional glimpse of another picture framed very faintly in the background of the local picture.

5.1 Protection ratio

The RF protection ratio[2, 3] is the minimum value of wanted-to-unwanted signal ratio, usually expressed in dBs at the receiver input, determined under specified conditions such that a specific reception quality is achieved at the receiver output. If 'non-precision offset' is used, there can be an improvement of 15 dB in the protection ratio (based on results obtained from tests using the CCIR 5-point subjective grading scale); that is, a lower protection ratio can be tolerated when using a non-precision offset as opposed to having no determined offset. An acceptable protection ratio for non-precision offset is typically 30 dB for n/3 line offset. For 'precision offset', there is a further improvement; approximately to a 22 dB protection ratio (representing a single grade improvement, on the CCIR 5-point scale, over a non-precision offset transmitter) for n/3 line offset.

5.2 The signal spectrum and signal offset

The term 'offset' does not mean an offset of the wanted carrier from its nominal channel frequency,

it is the *difference* between the actual frequencies of the *wanted* and *unwanted* carrier frequencies. For 'precision offset' the carriers of *each* transmitter must have a tolerance of ±1 Hz (±2 Hz collectively). The more basic 'non-precision' offset is allowed a relatively large (±500 Hz) tolerance — the situation originally pertaining for Rowridge but *not* for Lille Bouvigny, which was already using precision offset (as stated in Section 4).

The spectrum of the television signal is not continuous but consists of an accumulation of sidebands on either side of the carrier; these are placed

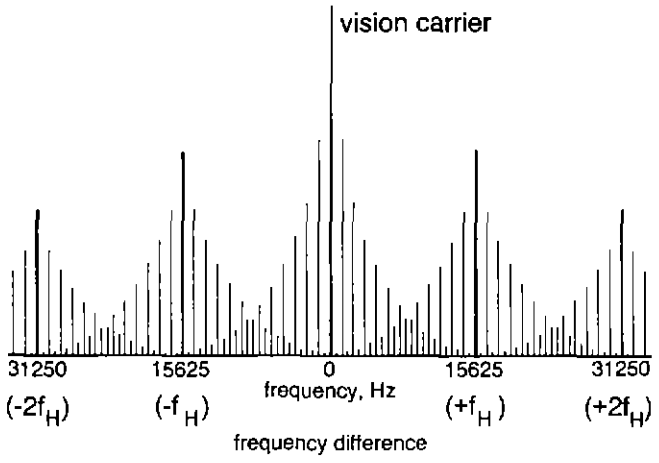

Fig. 4 - Spectral appearance of a 625-line television signal.

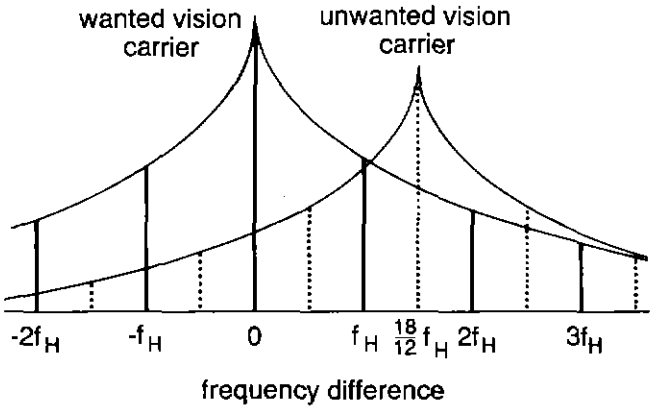

Fig. 5 - Optimum half-line offset.

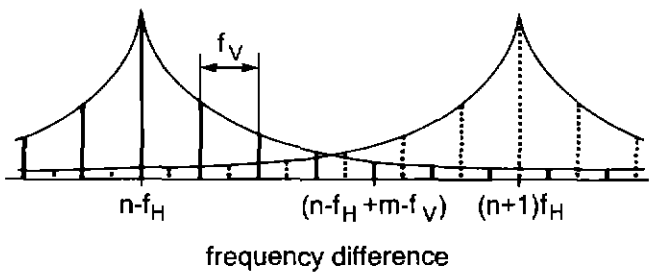

Fig. 6 - Precision offset, where f_v is the 50 Hz field frequency.

in multiples of line frequency (f_H) from the carrier itself, their levels being dependent on picture content. On either side of each line frequency sideband are further sideband elements, produced by the field and picture components (Fig. 4).

An interfering signal, situated so that its line harmonics are placed at the intermediate points of the spectrum (multiples of half-line frequency), causes the least visible interference (Fig. 5); but if they are placed at the line frequency harmonics of the wanted signal, the interference is at its worst.

As transmitters are placed in a rhombic[1] structure, there are likely to be three transmitters capable of causing CCI. Hence, to ensure there is minimum mutual interference, one-third line offset is used: so each transmitter has offset frequency relationships of $0\,f_H$, $-1/3\,f_H$, $+1/3\,f_H$. By using one-third instead of half-line offset, there is only a 2 to 3 dB worsening in the protection ratio. For non-precision offset, this condition can be held with reasonable stability. Patterning on pictures is basically the same at 5/3 and 10/3 line offset as for 1/3 offset. So, in practice, 5/3 is commonly[4] used because the FM sound carriers must be offset from each other by at least 20 kHz in order to give the sound signal the same protection as the vision signal.

A further improvement (of one impairment grade, as stated in sub-Section 5.1 above) can be achieved by ensuring that the 50 Hz (f_v) sidebands are *also* set at an intermediate position (Fig. 6); that is, at an odd multiple of half this frequency. This requires a maintained accuracy for the offset of ±2 Hz between both transmitters (i.e. precision offset). Thus, there is a non-moving pattern that self-cancels in phase over a two field period; the effect is to reduce the visibility of the pattern still further. It was this technique that was used for the Channel 24 transmission from Rowridge.

6. INSTALLING PRECISION OFFSET

Only the Channel 24 transmission was given a precision offset. Channels 21 and 27 transmissions were then available as 'control' channels for making comparisons with the 'treated' channel; this was to be in addition to comparisons that could be made using earlier results from the VHS recordings.

6.1 The choice of offset frequency

To maximise the benefits of precision offset, it is vital to have an offset frequency that is absolutely precise, as well as stable; otherwise, the situation could be worsened. The art of obtaining a correct offset frequency is a highly specialised one. For the

Rowridge Channel 24 channel, the frequency was determined by a method outlined in CCIR Rec. 655-1, Annex II[5].

6.2 The equipment required

The published (nominal) Channel 24 non-precision offset carrier frequency from Rowridge was 495 223958 Hz. This became 495 223990 Hz when the carrier was precision offset — a 32 Hz rise in frequency. Clearly, this incremental increase of the nominal frequency would have been ineffective if set within the ±500 Hz tolerance for non-precision offset. Hence, a precision offset tolerance of ±1 Hz had to be ensured for the new Channel 24 frequency, to alleviate the co-channel interference problem. A highly stable oscillator was clearly essential if this new carrier frequency value was to produce a good result. It should be noted, however, that other incremental changes in frequency could have provided similar reductions in CCI impairment (as indicated in the CCIR Rec. 655-1 Annex II publication); but any possible benefits would have been very marginal. Indeed, even tighter frequency tolerances would have been required for obtaining further (theoretically better) results. (It should also be noted that both transmitters must have a high level of oscillator stability; as stated previously, the 'offset' is *between* the carriers of the wanted and unwanted transmitters — see sub-Section 5.3.)

Commercial synthesised signal generators are generally available with the facility for applying a high stability external reference frequency; in this case a rubidium-standard oscillator was used. This oscillator has a frequency stability several orders better than the integral reference oscillator of the signal generator and holds the system to ±1 Hz required for precision offset.

At Rowridge, the frequency stability of the rubidium standard is further enhanced by comparing its output with the Rugby MSF 60 kHz standard frequency signal (by simple reference to an oscilloscope Lissajous display). The results of applying precision offset to Rowridge Channel 24 are summarised in the Conclusions which follow.

7. DISCUSSION OF RESULTS USING PRECISION OFFSET

The reception of Rowridge UHF television at the Poole relay station suffered occasional co-channel interference due to anomalous tropospheric propagation, which was then re-radiated. The interfering source was the TDF transmitter at Lille Bouvigny in north-western France.

Following confirmation by the French television authorities that transmissions for Lille Bouvigny used precision offset, the use of precision offset was experimentally undertaken on the Channel 24 transmission at Rowridge. The results have been compared with the other channels radiated from Rowridge, operating with conventional non-precision offsets, see Table 10 *(page 16)*. In addition, Figs. 7(a) - (d) *(see pages 8 - 9)* show a sample of off-screen stills* which clearly indicate the situation around 2106 hours on August 10th 1991: Channel 31 is unaffected by CCI (no Lille Bouvigny transmissions on this channel), Channel 24 (precision offset) is only slightly affected by CCI, Channel 27 (non-precision offset) is badly affected by CCI, and Channel 21 (non-precision offset) suffers noticeably worse effects of CCI than Channel 24.

The results from Table 10 show that, on the basis of CCIR Grade 3 or worse, Channel 24 with precision offset has suffered CCI for about 0.1% of the time. For Channels 21 and 27, operating non-precision, the corresponding figures are about 0.3% and 0.5% respectively. The Lille Bouvigny transmitter does not radiate on Channel 31 and therefore Channel 31 was free of CCI from this source. It is clear from these results that the visibility of CCI on the precision offset channel (Channel 24) is significantly less than for the two 'control' transmissions (i.e. Channels 21 and 27). These results are also shown in histogram form in Fig. 8(a) *(page 11)*. Fig. 8(b) shows, in similar form, the more extreme case for pictures of CCIR grade 2 or worse.

Further evidence can be obtained by comparing these results with an earlier analysis where all channels were operated non-precision offset, see Table 9 *(page 16)*. This reveals that Channel 24 had originally suffered from similar levels of CCI as did Channels 21 and 27. It is, therefore, very apparent that the precision offset of the Channel 24 transmissions has been beneficial.

8. CONCLUSIONS AND RECOMMENDATIONS

The consequent benefits of the Channel 24 precision-offset transmission are not confined to users

* However, it should be accepted that still photographs fail to show the absolute degradation of the received pictures because the variations of level and the movement of the patterning, cannot be shown clearly without numerous successive shots being taken. (As stated in Section 4, the minimising of pattern movement, produced by precision offset transmissions, gives an additional enhancement to picture quality.) Also, the VHS signal recording/playback parameters are of domestic VCR standard, and along with the limiting factors of the photographic processes used to reproduce the figures shown in this Report, some masking of the actual picture interference, as seen by the television viewer, is inevitable. Allowance, therefore, has to be taken of these shortfalls when assessing the picture quality as shown by these figures; but relative comparisons do give a reasonable indication of the improvement achieved for Channel 24.

of the Poole relay station; the quality of direct domestic reception of the Rowridge Channel 24 transmission, along the affected parts of southern England, would also have been improved. It is difficult to quantify this improvement, but computer predictions, together with the results of the measurements given in this Report, indicate that about 100 000 Rowridge viewers would benefit by up to one picture impairment grade, during periods of anomalous propagation.

It is recommended that arrangements for precision offset at Rowridge UHF transmitter should become part of the permanent transmission system. Furthermore, use of precision offset should be more widely considered in areas of persistent co-channel interference, since it has been shown in this Report that improvements in picture quality of approximately one CCIR picture grade can be achieved.

9. ACKNOWLEDGEMENTS

The authors would like to thank the staff of BBC Transmission for their co-operation in providing and maintaining the precision offset equipment at Rowridge, and also for facilitating the Research Department monitoring equipment at Poole.

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3. BROWN, A., 1968. Television co-channel interference: protection ratio for five-thirds line frequency precision offset of carriers with moving pictures. BBC Research Department Report No. 1968/21.

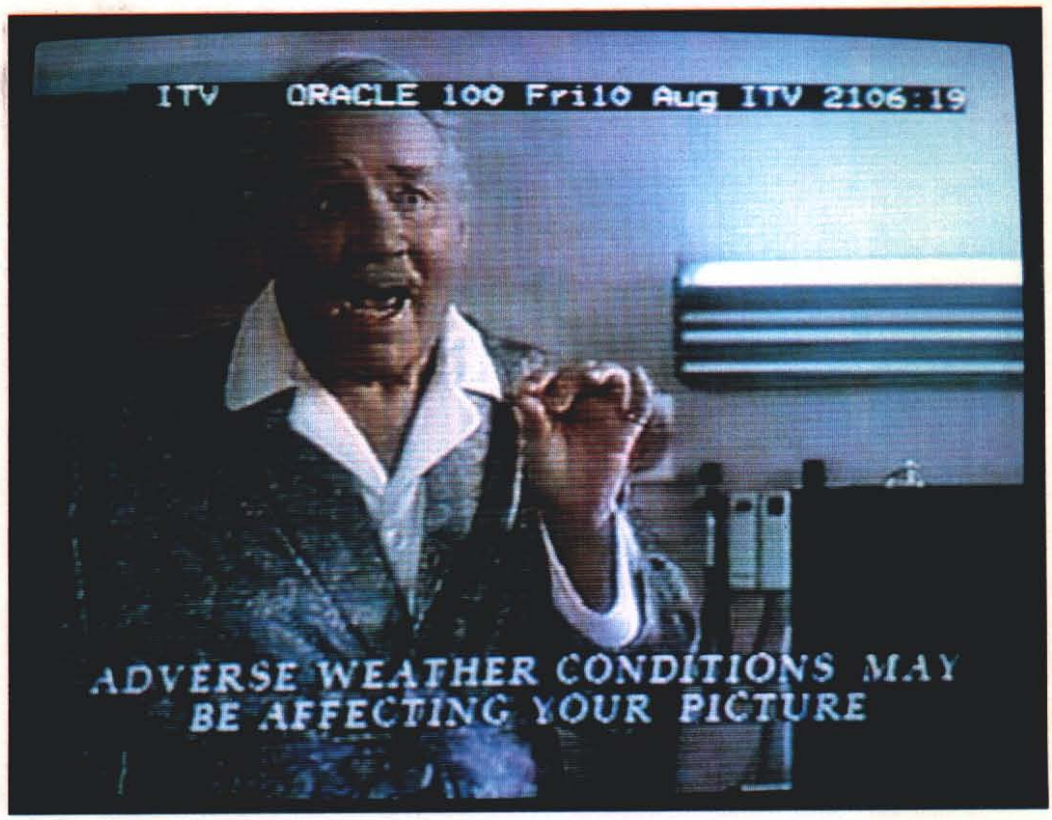
4. HARVEY, R.V., 1974. UHF television requirements for long-term and short-period carrier drive frequency stability. BBC Research Department Report No. BBC RD 1974/33.

5. CCIR Recommendation 655-1; Annex II. Geneva 1990.

(a) Channel 31 at 2105:56 BST (non-precision offset).

(b) Channel 24 at 2106:08 BST (with precision offset).

Fig. 7 (a) and (b) - Photographs taken from the VHS video recordings made at the Poole relay station on 10th August 1991.



(c) Channel 27 at 2106:19 BST (non-precision offset).

(d) Channel 21 at 2106:28 BST (non-precision offset).

Fig. 7 (c) and (d) - Photographs taken from the VHS video recordings made at the Poole relay station on 10th August 1991.

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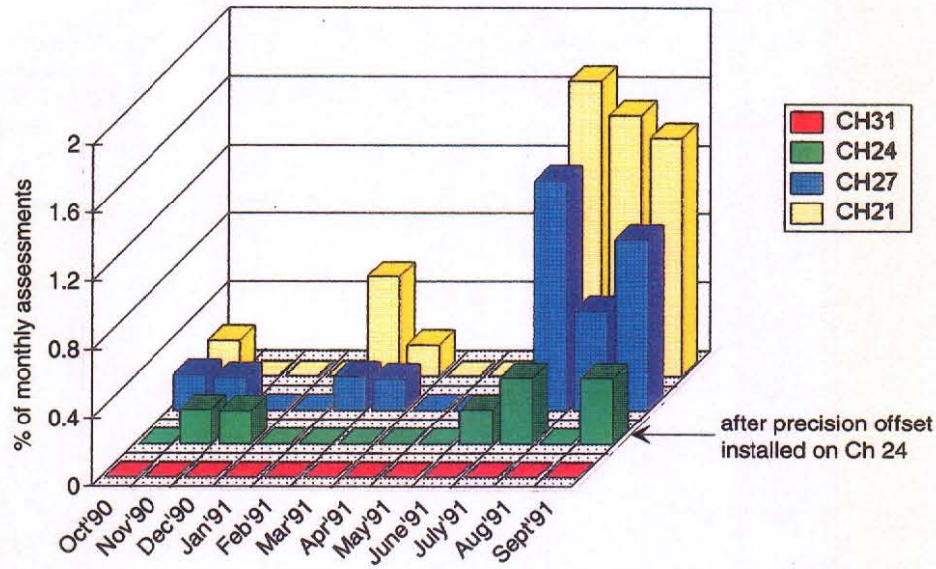
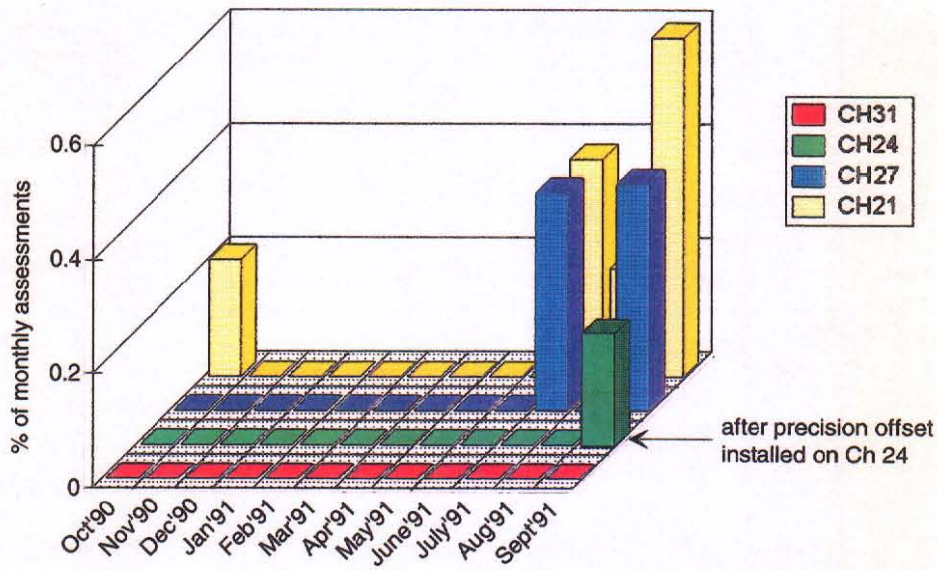


(a) CCIR impairment grade 3 or worse.



(b) CCIR impairment grade 2 or worse.

Fig. 8 - Assessment of impaired picture reception of Rowridge UHF TV signals received at Poole relay station with and without precision offset from Lille Bouvigny major interfering signal.

APPENDIX 1

Incidence of Co-channel Interference at Poole Relay Station

Incidence of co-channel interference for the 1985/86 investigations

Table 1: Channel 31 (BBC-1)

	Total samples	CCIR Impairment Grade					% of total assessment G3	% of total assessment G2 + G1	% of total assessment G3 + G2 + G1
		5	4	3	2	1			
Apr 85	529	529	-	-	-	-	0	0	0
May	544	542	1	1	-	-	0.184	0	0.184
Jun	522	515	7	-	-	-	0	0	0
Jul	534	512	22	-	-	-	0	0	0
Aug	564	537	27	-	-	-	0	0	0
Sep	530	484	45	-	1	-	0	0.189	0.189
Oct	532	522	8	1	1	-	0.188	0.188	0.376
Nov	476	476	-	-	-	-	0	0	0
Dec	501	499	2	-	-	-	0	0	0
Jan 86	531	531	-	-	-	-	0	0	0
Feb	487	486	1	-	-	-	0	0	0
Mar	539	539	-	-	-	-	0	0	0
Total	6289	6172	113	2	2	-	0.03	0.03	0.06

Table 2: Channel 24 (BBC-2)

	Total samples	CCIR Impairment Grade					% of total assessment G3	% of total assessment G2 + G1	% of total assessment G3 + G2 + G1
		5	4	3	2	1			
Apr 85	505	504	1	-	-	-	0	0	0
May	536	532	3	1	-	-	0.187	0	0.187
Jun	509	457	50	2	-	-	0.393	0	0.393
Jul	536	400	123	11	2	-	2.05	0.373	2.42
Aug	566	162	268	124	10	2	21.90	2.12	24.02
Sep	527	342	148	23	11	3	4.36	2.66	7.02
Oct	485	308	144	21	7	5	4.33	2.47	6.80
Nov	470	432	36	2	-	-	0.43	0	0.43
Dec	454	410	42	2	-	-	0.44	0	0.44
Jan 86	488	473	14	1	-	-	0.21	0	0.21
Feb	472	439	30	3	-	-	0.64	0	0.64
Mar	532	522	9	1	-	-	0.19	0	0.19
Total	6080	4981	868	191	30	10	3.1	0.66	3.8

Appendix 1 (cont.)

Incidence of co-channel interference for the 1985/86 investigations

Table 3: Channel 27 (ITV)

	Total samples	CCIR Impairment Grade					% of total assessment G3	% of total assessment G2 + G1	% of total assessment G3 + G2 + G1
		5	4	3	2	1			
Apr 85	532	527	5	-	-	-	0	0	0
May	559	546	10	3	-	-	0.536	0	0.53
Jun	537	446	87	4	-	-	0.75	0	0.75
Jul	546	404	121	18	3	-	3.29	0.49	3.85
Aug	559	399	114	33	11	2	5.9	2.33	8.23
Sep	541	366	126	31	16	2	5.73	3.33	9.06
Oct	556	424	105	14	6	7	2.52	2.34	4.86
Nov	519	494	22	3	-	-	0.58	0	0.58
Dec	521	493	27	1	-	-	0.19	0	0.19
Jan 86	566	499	64	3	-	-	0.53	0	0.53
Feb	512	473	38	1	-	-	0.19	0	0.19
Mar	566	521	42	3	-	-	0.53	0	0.53
Total	6514	5592	761	114	36	11	1.75	0.72	2.47

Table 4: Channel 21 (CH 4)

	Total samples	CCIR Impairment Grade					% of total assessment G3	% of total assessment G2 + G1	% of total assessment G3 + G2 + G1
		5	4	3	2	1			
Apr 85	500	499	1	-	-	-	0	0	0
May	509	500	7	2	-	-	0.39	0	0.39
Jun	495	390	104	1	-	-	0.20	0	0.20
Jul	508	340	148	15	3	2	2.95	0.98	3.94
Aug	514	426	75	8	4	1	1.56	0.97	2.53
Sep	489	366	110	7	2	4	1.43	1.23	2.66
Oct	500	458	25	6	4	7	1.2	2.20	3.4
Nov	498	480	18	-	-	-	0	0	0
Dec	491	484	7	-	-	-	0	0	0
Jan 86	538	532	6	-	-	-	0	0	0
Feb	484	480	4	-	-	-	0	0	0
Mar	532	525	7	-	-	-	0	0	0
Total	6058	5480	512	39	13	14	0.64	0.46	1.09

Appendix 1 (cont.)

Incidence of co-channel interference for the 1990/91 investigations

Table 5: Channel 31 (BBC-1)

	Total samples	CCIR Impairment Grade					% of total assessment G2 + G1	% of total assessment G3 + G2 + G1
		5	4	3	2	1		
Oct 90	488	488	-	-	-	-	0	0
Nov	530	530	-	-	-	-	0	0
Dec	553	553	-	-	-	-	0	0
Jan 91	554	554	-	-	-	-	0	0
Feb	521	521	-	-	-	-	0	0
Mar	549	549	-	-	-	-	0	0
Apr	504	504	-	-	-	-	0	0
May	526	526	-	-	-	-	0	0
Jun	508	508	-	-	-	-	0	0
Jul	521	521	-	-	-	-	0	0
Aug	524	524	-	-	-	-	0	0
Sep	504	503	1	-	-	-	0	0
Total	6282	6281	1	-	-	-	0	0

Table 6: Channel 24 (BBC-2)

	Total samples	CCIR Impairment Grade					% of total assessment G2 + G1	% of total assessment G3 + G2 + G1
		5	4	3	2	1		
Oct 90	469	464	5	-	-	-	0	0
Nov	504	502	1	1	-	-	0	0.198
Dec	529	527	1	1	-	-	0	0.189
Jan 91	527	526	1	-	-	-	0	0
Feb	516	514	2	-	-	-	0	0
Mar	553	548	5	-	-	-	0	0
Apr	510	507	3	-	-	-	0	0
May	524	523	1	-	-	-	0	0
Jun	503	497	5	1	-	-	0	0.199
Jul	524	516	6	2	-	-	0	0.382
Aug	526	512	14	-	-	-	0	0
Sep	507	496	9	1	1	-	0.197	0.197
Total	6192	6139	53	6	1	-	0.0163	0.113

Appendix 1 (cont.)

Incidence of co-channel interference for the 1990/91 investigations

Table 7: Channel 27 (ITV)

	Total samples	CCIR Impairment Grade					% of total assessment G2 + G1	% of total assessment G3 + G2 + G1
		5	4	3	2	1		
Oct 90	491	488	2	1	-	-	0	0.204
Nov	538	535	2	1	-	-	0	0.186
Dec	558	558	-	-	-	-	0	0
Jan 91	557	557	-	-	-	-	0	0
Feb	522	520	1	1	-	-	0	0.192
Mar	556	553	2	1	-	-	0	0.180
Apr	509	505	4	-	-	-	0	0
May	526	526	-	-	-	-	0	0
Jun	508	508	-	-	-	-	0	0
Jul	524	514	3	5	1	1	0.382	1.336
Aug	527	517	7	3	-	-	0	0.569
Sep	506	491	10	3	1	1	0.396	0.988
Total	6322	6272	31	15	2	2	0.063	0.301

Table 8: Channel 21 (CH 4)

	Total samples	CCIR Impairment Grade					% of total assessment G2 + G1	% of total assessment G3 + G2 + G1
		5	4	3	2	1		
Oct 90	488	487	-	-	1	-	0.205	0.205
Nov	540	538	2	-	-	-	0	0
Dec	557	556	1	-	-	-	0	0
Jan 91	557	557	-	-	-	-	0	0
Feb	522	519	-	3	-	-	0	0.575
Mar	556	555	-	1	-	-	0	0.180
Apr	509	507	2	-	-	-	0	0
May	526	526	-	-	-	-	0	0
Jun	508	508	-	-	-	-	0	0
Jul	524	507	8	7	1	1	0.382	1.717
Aug	527	496	23	7	1	-	0.190	1.518
Sep	505	479	19	4	2	1	0.594	1.386
Total	6319	6235	55	22	5	2	0.111	0.459

Appendix 1 (cont.)

Table 9: Co-channel interference at Poole relay station for total period April 1985 to March 1986.

Impairment grade 2 or worse in % of time				Impairment grade 3 or worse in % of time			
Ch 31 (BBC-1)	Ch 24 (BBC-2)	Ch 27 (ITV)	Ch 21 (CH 4)	Ch 31 (BBC-1)	Ch 24 (BBC-2)	Ch 27 (ITV)	Ch 21 (CH 4)
0.03	0.66	0.72	0.46	0.06	3.80	2.47	1.09

Table 10: Co-channel interference at Poole relay station for total period October 1990 to September 1991.

Impairment grade 2 or worse in % of time				Impairment grade 3 or worse in % of time			
Ch 31 (BBC-1)	Ch 24 (BBC-2)	Ch 27 (ITV)	Ch 21 (CH 4)	Ch 31 (BBC-1)	Ch 24 (BBC-2)	Ch 27 (ITV)	Ch 21 (CH 4)
0	0.016	0.063	0.111	0	0.113	0.301	0.459

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